

Bacotia*-like new genus of the family Psychidae (Lepidoptera) from Taiwan, with a discussion on its systematic position

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Abstract *Tayalopsyche* gen. nov. of Psychidae is described from the mountain region of Taiwan based on *Tayalopsyche spinidomifera* sp. nov. The genus somewhat resembles *Bacotia*, but is more plesiomorphic than it in having the cellula intrusa in the forewing, well-developed uncal lobes and an invaginated pouch on the diaphragma of the male genitalia. The larval case of the new species is unique in being ornamented with elongate plant fragments erected on its outer surface.

Key words Psychidae, *Tayalopsyche spinidomifera* gen. et sp. nov., systematics, larval case, Taiwan.

Introduction

In the early summer of 1999 we collected a unique pupation case of a psychid at the mountain region of Huanshan in central Taiwan. It was fixed on the underside of a leaf of *Miscanthus*-like grass *ca* 1 m above the ground. It is somewhat similar to cases of *Psyche* and its allies in general shape, *i. e.* small, cylindrical, rather thick and covered with plant materials, but it is unusual in having attached longish fragments of plants erect at almost right angles to its outer surface, so that it appears like spinous. Fortunately a small male moth emerged from the case. At a glance, the moth may be easily mistaken for the genus *Proutia* Tutt, 1899 or *Bacotia* Tutt, 1899, as it is extremely similar to them in its habitus including the bipectinate antennae with dorsally bare pectinations, moderately narrow and almost uniformly blackish brown wings. However, as the result of morphological study on this specimen, we concluded that it unexpectedly represents an undescribed genus of the subfamily “Psycheoidinae” (*sensu* Kozhantshikov, 1969). It has both the accessory cell and the cellula intrusa in the forewing discoidal cells as found in most of the primitive psychid genera such as *Diplodoma* Zeller, 1852, *Penestoglossa* Rogenhofer, 1875 and *Melasina* Boisduval, 1840, and its male genitalia have the deeply bilobed uncus with a pair of ventrally directed hook-like points as seen in *Bacotia* and *Luffia* Tutt, 1899 among the genera resembling the genus *Psyche* Shrank, 1801. Although we have only a male specimen, it has so many distinctive morphological characters that we do not hesitate to found a new genus and a new species for it as follows. The holotype of the new species will be eventually donated to the insect collection of National Taiwan University, Taipei.

* Contribution from the Biosystematics Laboratory, Graduate School of Social and Cultural Studies, Kyushu University (No. 89). This study was in part supported by a Grant-in-Aid for JSPS fellowships from the Ministry of Education, Science, Sports and Culture, Japan (No. 11003364).

Materials and methods

The material of the new genus and species is only the male specimen mentioned above. We compared it with male specimens of *Bacotia sakabei* Seino, 1981, *Bacotia nepalica* Dierl, 1966, *Luffia lapidella* (Goeze, 1783), *Proutia betulina* (Zeller, 1893), *Psyche casta* (Pallas, 1767), *Psyche nipponica* (Hori, 1926) and several undescribed species of *Proutia* and *Psyche*.

The holotype of the new species. Coloration and size of body were observed and measured based on the expanded dried specimen. In order to recognize obscure markings, the right forewings were slide-mounted and observed on dark back ground with lights of different directions. Wing shape, size and venation were observed on the slide-mounted right wings that were cleared by removing scales from the wing surface with a minute cotton ball in 80% ethanol. For integumental morphology, the posterior 1/2 of abdomen and left legs excluding coxae were removed from the body and placed in 15% KOH solution at 95°C for about 10 minutes, then washed in distilled water, treated with 10% acetic acid, again washed in distilled water, and observed in 80% glycerol under a stereoscopic microscope (magnification up to $\times 260$) and a compound microscope (magnification up to $\times 600$). The wing scales were observed on the slides mounted with Balsam Canadense. Body structure was illustrated by using an ocular section scale and graph paper. All photographs were taken with a NIKON Coolpix 990 digital camera together with conversion lenses and the microscopes.

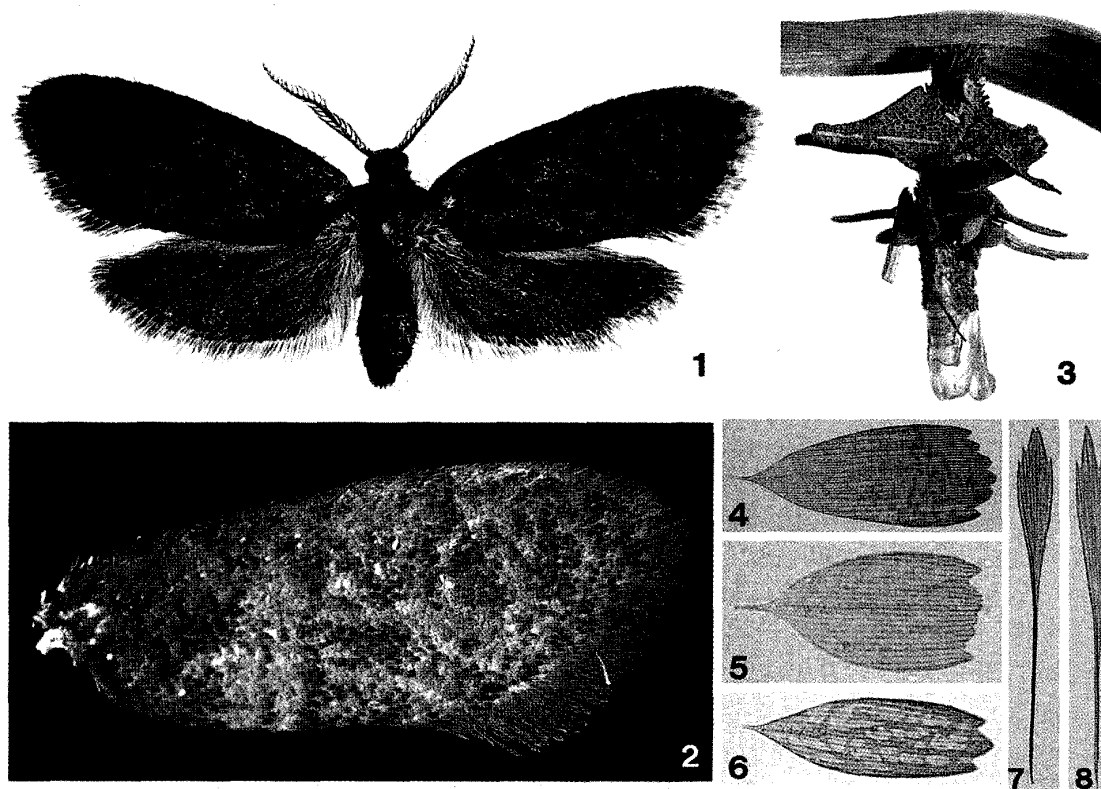
Other materials. Markings and venation of wings, the male genitalia and legs were treated and observed using the same methods as for the holotype of the new species.

Results including descriptions

Tayalopsyche gen. nov.

Type species. *Tayalopsyche spinidomifera* sp. nov.

Description. Male adult (Fig. 1). Small-sized psychid. Head slightly narrower than thorax; frons densely and smoothly covered with broad scales directed ventrally; vertex also similarly covered with more elongate scales directed anteriorly; long hair-like scales erected on posteroventral portion of head. Compound eyes moderately large, separated by frons for nearly 1/2 width of head; lateral ocelli absent. Antenna extending slightly proximad of the middle of forewing costa; flagellomere with a pair of pectinations, covered with scales on dorsal surface of shaft; pectinations bare dorsally, bearing long sensory hairs ventrally, nearly $2\times$ as long as shafts in middle flagellomeres. Mouthparts reduced, represented by only a pair of slender labial palpi arising close to each other, and bearing elongate scales. Thoracic nota smoothly covered with broad scales; mesoscutellum covered with small short scales; tegula densely covered with longish narrow scales posteriorly. Wings narrow, resembling *Bacotia* spp.; forewing apex roundly pointed posterior to tip of R_{4+5} ; hindwing slightly longer than 2/3 of forewing, widest before its middle, tapering to rather strongly but roundly pointed apex at tip of R_s . Wings blackish brown above, indistinctly and irregularly mottled with dark brown scales (Fig. 2); upper surface densely covered with broad scales (Figs 4–8). Wing venation (Figs 9 & 10) rather complete, except for fusion of R_4 and R_5 in forewing and absence of 1 branch of M in hindwing. Forewing veins all free; Sc ending in costa slightly proximad of discocellular level; discoidal cell 2/3 as long as forewing, narrow basally, much dilating apically, and with accessory cell and cellula intrusa, which are 1/4 as long as discoidal cell; R_1 arising from the middle of the cell; R_{4+5} ending slightly before apex of



Figs 1-8. Holotype male of *Tayalopsyche spinidomifera* gen. & sp. nov. 1. Whole insect. 2. Right forewing showing obscure mottles. 3. Pupation case. 4. Upper scale of forewing upperside ($175\ \mu$ long). 5. Lower scale of forewing upperside ($153\ \mu$ long). 6. Scale of hindwing upperside ($133\ \mu$ long). 7. Fringe scale of forewing ($530\ \mu$ long). 8. Fringe scale of hindwing ($450\ \mu$ long).

wing; CuP disappearing before level of origin of CuA₂; cell A₁ slightly shorter than 1/2 length of A₁₊₂; A₁₊₂ ending at tornus. Hindwing veins all free; discoidal cell slightly longer than 1/2 length of hindwing, gradually dilating apically; posterior portion of the cell longer than anterior portion; lower discocellular oblique; Rs ending at wing apex; M-stem simple in discoidal cell, so that cellula intrusa absent. Legs (Figs 11-13) moderately long and slender; fore tibia with long epiphysis, arising from its basal 1/3 and extending apically slightly beyond tip of the tibia; mid- and hind tibiae with one and two pairs of spurs, respectively; tarsi slender. Legs smoothly covered with scales; hind femur clothed ventrally with long hair-like scales; no long hairs on hind tibia. Abdomen covered with broad scales, and bearing a few hair-like scales on posterior margins of posterior terga; 8th abdominal tergum weakly curving ventrally in lateral aspect as in genera such as *Proutia* and *Psyche*; 8th sternum smaller and somewhat shorter than 7th sternum.

Male genitalia (Figs 14-16). Genital ring suberect to long axis of abdomen; in lateral aspect, dorsum triangular in shape, as long as high, with apical portion of uncus ventrally curved hook-like; tegumen strongly tapered ventrally; vinculum moderately broad, with a small projection anteriorly near its middle, with a posterior submarginal ridge and an oblique ridge running from the projection to dorsal extremity of the submarginal ridge; saccus developed but short. In dorsal aspect, tegumen almost 1/2 as long as whole length of dorsum, with a weak dorsal ridge demarcating basal portion of uncus; uncus as long as tegumen, divided into a pair of triangular components, which are attached to each other at

dorsomedian portion, and sharply pointed apically. Diaphragma deeply invaginated into a rounded pocket above transtillar arms; subanal plate undeveloped. Valva moderately large, quadrate on basal 1/2 with angulated ventrodistal corner, divided into ampulla and harpe on apical 1/2; ampulla broader than thick, and harpe slender, shorter than ampulla and with several spinules apically; ventroproximal portions of valvae not so widely separated as in *Proutia* and *Psyche*; transtillar arm long. Vallum penis large, well projected distally as free pad, which bears many rather long setae basally, and short stiff setae apically. Phallus moderately thick, slightly longer than height of genital ring, only weakly curved ventrally; proximal portion obliquely opening at left side, vesica obliquely opening at right side; a weakly sclerotized ring like cornutus with many minute denticles on apical 1/2 of phallus.

Female adult. Unknown.

Male pupa. Similar to those of *Proutia* and *Psyche*; labial sheath extending to the middle between labrum and apical portion of fore coxa, with median suture dividing palpi extending to its middle; maxilla as long as wide, roughly regular triangle in shape, nearly 1/2 as long as labial sheath; foreleg extending to 0.4 length between tips of fore coxa and midleg. Fourth to 8th abdominal dorsa each with an anterior row of spinules which are arranged in a line in 4th to 7th dorsa and in a small mass in 8th dorsum. A blunt conical projection situated just dorsal to a pair of anal hooks.

Larva. Exuviae of final instar showing head and thoracic nota pale in colour with dark brown markings; abdominal cuticle whitish.

Larval case (Fig. 3). Cylindrical, 4× as long as thick, only slightly tapered to both ends; covered with minute scales of plant material, and bearing many longish, usually slender plant material erected on outer surface of case. Pupation case with three cut slits on posterior portion, each slit nearly 1/3 as long as case, and roughly spun with silk to close slit; these slits were opened by pupa when it protruded from the case for emergence. Pupation case attached to the underside of a leaf at right angle, with entire circular margin of anterior opening tightly attached on the substratum with silk.

Distribution. Taiwan.

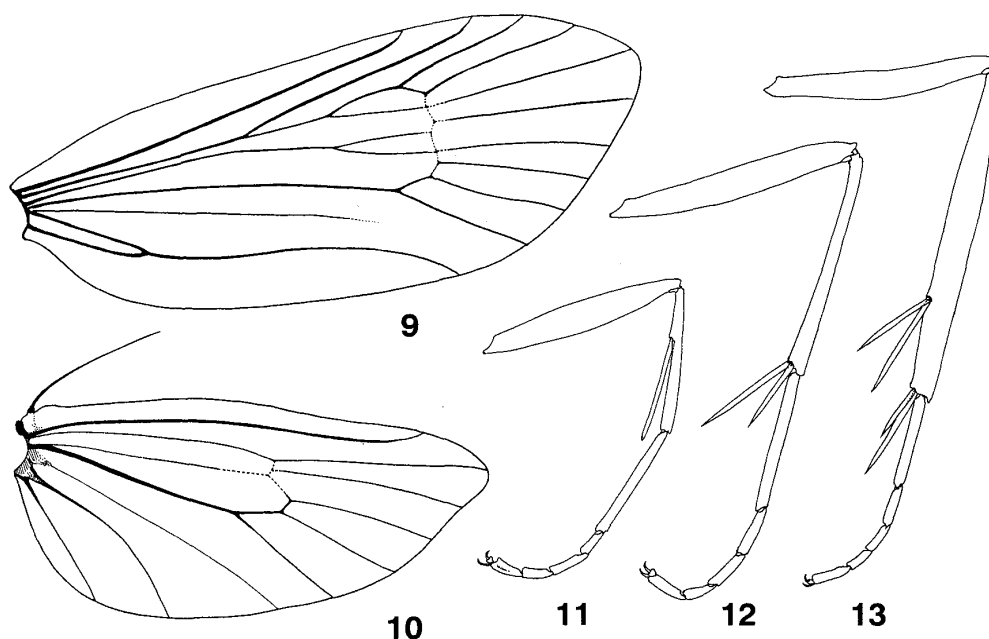
Etymology. Tayal (name of one of main native tribes of Taiwan) + *Psyche*.

Gender. Feminine.

Remarks. In general appearance the new genus is similar to *Proutia* and *Bacotia*. It is distinct from them in having both the accessory cell and the cellula intrusa in the forewing. The male genitalia of the new genus are somewhat similar to those of *Bacotia* and *Luffia* in the shape of dorsum, but the presence of deeply invaginated diaphragma is unique to the new genus. The final instar larva of the new genus differs from that of *Bacotia* in the dark marking on the pale ground on the head and thoracic nota. For the systematic position of the new genus see the discussion.

***Tayalopsyche spinidomifera* sp. nov.**

Male (Fig. 1). Small-sized psychid. Antenna with 24 flagellomeres. Head and thoracic nota densely covered with blackish brown scales with a slight dark purplish tinge; thoracic pleura with greyish brown hair-like scales. Abdomen covered with blackish brown broad scales and with a few hair-like scales along posterior margin of each segment, ventrally with dark brown scales. Legs (Figs 11–13) covered with blackish brown scales: ventral hair-like



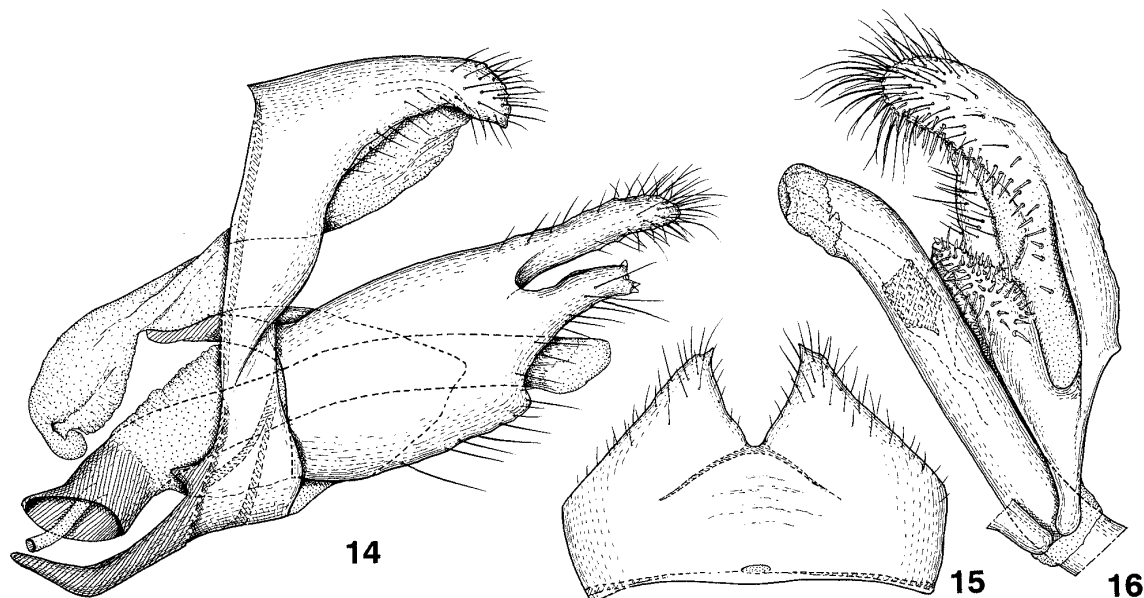
Figs 9–13. Holotype male of *Tayalopsyche spinidomifera* gen. & sp. nov. 9. Forewing venation. 10. Hindwing venation. 11. Left foreleg. 12. Left midleg. 13. Left hindleg.

scales and scales on tibia and tarsus of hind femur greyish brown; scales on spurs paler. Shape of legs including epiphysis and spurs illustrated as in Figs 11–13. Epiphysis of fore tibia $3/4$ as long as the tibia; anterior and posterior spurs of mid tibia $2/3$ and $1/2$ as long as tibia, respectively; anterior and posterior middle spurs of hind tibia 0.27 and $0.35\times$ as long as the tibia, respectively, and anterior and posterior terminal spurs of hind tibia 0.19 and $0.29\times$ as long as the tibia, respectively.

Forewing (Fig. 9) narrow, $2.47\times$ as long as wide (excluding fringe); costa slightly arched subbasally, then almost straight, and gradually curved subapically to roundly pointed apex; termen slightly arched; tornus broadly rounded; hind margin tapered to wing base on its basal $1/3$, apical $2/3$ almost straight. Hind wing (Fig. 10) $2/3$ as long as forewing or $2.1\times$ as long as wide (excluding fringe), widest at $1/3$; costa weakly arched for middle $1/3$; apex roundly produced; termen oblique, almost weakly arched between tips of M_3 and CuA_2 ; Sc ending in subapical portion of wing.

Forewing upperside blackish brown with a slight dark purplish gloss; in some lights dark greyish brown mottling appearing as in Fig. 2; upper scales (Fig. 4) $160\text{--}190\ \mu$ long, $50\text{--}75\ \mu$ wide, broad, weakly narrowed towards base on basal $1/4\text{--}1/3$, with 5–8 (usually 6–7) small dentations on distal margin, apices of dentations either acute or blunt; lower scales (Fig. 5) $95\text{--}110\ \mu$ long, $45\text{--}50\ \mu$ wide, similar to upper ones in shape, smaller with smaller numbers of distal dentations; scales of fringe (Fig. 7) elongate, almost stalk-like on its basal $1/3\text{--}1/2$, apical portion narrow and lanceolate, with several sharply pointed dentations. Hindwing upperside dark brown, costal area light grey; hindwing upperside covered with scales (Fig. 6) $120\text{--}150\ \mu$ long, $40\text{--}50\ \mu$ wide, slightly shorter than upper scales of forewing upperside, the scales with 3–5 distal dentations; scales of fringe (Fig. 8) similar to those of forewing.

Male genitalia (Figs 14–16). Dorsum $0.8\times$ as long as height of tegumen; uncus $3/4$ as long as tegumen; vinculum $2/3$ as high as tegumen; saccus $1/3$ as long as height of ring; invagina-



Figs 14–16. Holotype male of *Tayalopsyche spinidomifera* gen. & sp. nov. 14. Whole genitalia, lateral aspect. 15. Dorsum, dorsal aspect. 16. Left valva with vallum penis and apical 1/2 of phallus, dorsal aspect.

tion of ventral portion of diaphragma extending anteriorly much beyond apices of transtillar arms; length of valva measured from its ventroproximal corner to apex of ampulla $0.85\times$ of height of ring; ventrodistal corner of main portion of valva rectangular in lateral aspect; ampulla $0.43\times$ as long as length of valva; process of harpe $3/5$ as long as ampulla and with 3–4 denticles at apex; phallus $1.3\times$ as long as height of ring, almost $10\times$ as long as thick; distal portion of vallum penis extending to $2/5$ of valva.

Measurements. Length of body 4.2 mm; length of forewing including fringe 5.8 mm; length of forewing excluding fringe 4.9 mm; length of hindwing excluding fringe 4.2 mm; wing expanse 12.5 mm; length of antenna in dried condition 2.5 mm.

Holotype ♂. Huanshan-Suchilanchi, 1,600 m, nr Lishan, Taichung-Hs., Taiwan, June 19, 1999 (fixed case), July 1, 1999 (adult emerged), T. Saigusa & M. Sugimoto leg. Pinned specimen without right wings, left legs and apical 1/2 of abdomen; right wings without scales, forewing scales, and hindwing scales were mounted on a slide, respectively; apical portion of abdomen with genitalia and left legs are preserved in glycerol in a microvial.

Pupation case (Fig. 3). 8.0 mm in length, 1.7 mm in thickness at the middle; almost cylindrical, only slightly narrowed anteriorly, somewhat tapered near posterior opening; outer surface entirely covered with minute oval scales (0.3×0.2 mm) of plant material which are smaller on posterior portion of case; some 20 slender plant materials (mostly part of leaves of several kinds of plants) attached on outer surface, and these materials erected almost rectangularly to long axis of case. Three slits cut from posterior opening of case 1.7, 1.9 and 2.0 mm long, respectively. Inner surface of case smooth, without a fluffy silk layer inside the case.

Remarks. This new species is superficially similar to narrow-winged species of *Proutia* or *Bacotia*, and only distinguished from them when the generic characters of the wing venation and male genitalia are examined.

Etymology. The specific name *spinidomifera*: spini (spine)+domus (house)+fera (carry). It is based on the larva bearing a case of spiny appearance.

Discussion

1. Morphology of male genitalia

The area between the anus and the manica in the male genitalia is simple and usually widely membranous in the family Psychidae. The absence of the gnathos in the male genitalia is one of the advanced characters of the family Psychidae (Saigusa, 1962; Nielsen, 1978). In some genera such as *Diplodoma* and *Paranarychia* Saigusa, 1962, a weakly sclerotized subanal plate (sometimes called subscaphium) appears in the middle of the diaphragma. In the genus *Kozhantshikovia* Saigusa, 1962, this subanal plate is developed as a strongly sclerotized spinous sclerite.

In the present new genus the subanal plate is not formed, but the lower portion of the diaphragma is deeply invaginated into a narrow, elongate pocket or pouch, of which the bottom extends anteriorly beyond the apices of the transtillar arms. This character state of the diaphragma has not been recorded in the family Psychidae as far as we know. The function of this membranous pocket is unknown. A similar pouch is formed in some Lepidoptera, such as the genus *Argyronome* and its allies of the family Nymphalidae (Shirôzu & Yamamoto, 1953; Shirôzu & Saigusa, 1973), and in these genera the pouch seems to be a gland because it contains an adorous substance (unpublished data of Saigusa).

In the family Psychidae, the uncus is bilobed apically in many, mostly primitive genera. However, even in these genera the incision between the two lobes is usually shallow, and the distinct border between uncus and tegumen disappears. Among the Palaearctic genera only *Melasina* has well-developed, longish uncal lobes (Kozhanchikov, 1969). The uncal lobes of the new genus are as large as those of *Melasina*, and a fairly distinct border between them and the tegumen is exceptionally developed.

2. Structure of larval case

The new genus is similar to *Bacotia*, *Psyche* and its allies in general shape of the larval case and the manner of fixing the pupation case to the substratum (Hättenschwiler, 1970; Herrmann, 1994; our unpublished observations). However, in these genera the outer surface of the case is covered with small but broad pieces of leaves and bark, or fine stems of grasses. These coverings are tightly attached to the outer surface horizontally with their posterior portions sometimes projecting obliquely (pieces of leaves and barks), or they are attached longitudinally along the long axis of the case (fine stem of grasses) (Kozhanchikov, 1969; Herrmann, 1994; our observation on Japanese species).

In the new genus most of larger plant materials are tightly attached to the outer surface of the case not horizontally but almost perpendicularly to the long axis of the case, so that only one extremity of the long axis of the material is attached to the surface. We have never observed a similarly ornamented larval case in the genera *Bacotia*, *Luffia*, *Proutia*, *Psyche* and *Bruandia*.

3. Habitat

The only known specimen of the new species was found in summer green broad-leaved forest

at 1,600 m alt. in central Taiwan. As the pupation case was found on the underside of grass along a mountain trail and the plant materials covering the larval case consist of pieces of various kinds of higher plants, but do not include lichens or mosses, we speculate that the larva of the new species lives on the ground and feeds on dead or decomposing materials of higher plants as some Japanese species of the genus *Proutia* do.

4. Systematic position of the genus *Tayalopsyche*

The systematics of the family Psychidae is by no means sufficiently established at the present (Robinson & Davis, 1999), so that it is difficult to discuss the precise systematic position of the new genus. At least it is certain that the genus does not belong to the subfamily Oiketicinae (Psychinae of Kozhanchikov, 1969). This subfamily is characterized by the apomorphic state of the vein CuP fused with the middle of the vein A_{1+2} , which often emits posteriorly a short branch often referred as the apical portion of the vein A_2 . In the new genus, the vein CuP of the forewing is plesiomorphically free apically and vein A_{1+2} does not emit any branch. Therefore the new genus belongs to the subfamily "Psycheoidinae" (unavailable subfamily name) of Kozhanchikov (1969).

As the new genus has uniserial anterior spinules on the abdominal dorsa of the pupa, and the harpe of the male genitalia has several denticles at the tip, the genus does not belong to the subfamily Taleporiinae (Hättenschwiler, 1985). The new genus resembles the genera *Dissoctenioides* Rebel, 1935, *Pseudofumea* Rebel, 1935, *Bacotia* and *Luffia* in the basic structures of the male genitalia, and of the male antennae. In these four genera, the male genital dorsum is well developed, triangular in lateral aspect, and the uncus is divided into a pair of triangular processes, each of which has a ventrally curved hook apically, and shape and structure of valvae are also similar among these genera (Kozhanchikov, 1969). The male flagellomeres of these genera have a pair of pectinations, which are completely bare dorsally and bear sensory hairs ventrally. *Dissoctenioides* and *Bacotia* (and probably *Luffia*) are similar to the new genus in having the accessory cell in the forewing, but the forewing cellula intrusa that is distinctly formed in the new genus, is absent in these two (or three) genera. In *Pseudofumea* both accessory cell and cellula intrusa disappear. Therefore, the new genus is plesiomorphic to these genera in the wing venation.

The female of *Dissoctenioides* has well-developed wings, while those of three other genera are almost or completely apterous (Kozhanchikov, 1969; Dierl, 1966; Seino, 1981). It is important to find the female of the new genus for further discussion on its systematic position.

The new genus is apparently more primitive than *Psyche* and its allies (*Proutia* and *Bruandia* Tutt, 1900). It shares the following characters with them: maculated larval cranium, cylindrical larval case, anterior opening of pupation case circularly attached to the substratum, uniserial anterior spinules on abdominal dorsa of pupa, bipectinate male antenna, and several denticles at tip of male genital harpe. However, the *Psyche* group is more advanced in comparison with the new genus in the absence of the accessory cell of forewing discoidal cell, in distal origin of vein R_1 , and in much reduced male genital dorsum having a pair of short blunt lobes on the uncus (Dierl, 1964; Kozhanchikov, 1969).

It is assumed that the new genus is one of the earlier offshoots of the group consisting of the above-mentioned genera. Primitive genera comprising the group hitherto have been known mostly from the Western Palaearctic Region, *i. e.* *Dissoctenioides* and *Pseudofumea* from the Atlas Mountains, *Luffia* from Europe, *Bacotia* from Europe, Nepal and Japan. Judging from the occurrence of the new genus in the mountain region of Taiwan, we may expect

additional primitive genera of this group in Temperate Eastern Asia, particularly in Continental China.

Acknowledgements

One of us, Sugimoto, expresses her thanks to Prof. O. Yata, Prof. H. Shima and Associate Prof. K. Araya of Kyushu University for their constant guidance.

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摘 要

Bacotia 属に類似した台湾産のミノガ科の 1 新属とその系統的位罫について (鱗翅目)
(杉本美華・三枝豊平)

台湾中部の台中県梨山環山の落葉広葉樹林で採集した小形のミノガの蛹化ミノから得られた 1 頭の雄に基づいて新属新種 *Tayalopsyche spinidomifera* を記載した. 本種は前翅がやや尖った小形黒褐色のミノガで, 一見すると *Bacotia* 属に外観が類似しているが, 中脈分岐によって cellula intrusa が中室内に形成され, 雄交尾器の uncus が大形で, tegumen との間に判然とした境界が認められ, diaphragma が深くポケット状に陥入するなどの形質によって顕著に異なっている.

本属は雄交尾器の背域の基本構造と valva の概形などから, *Dissoctenioides* (アトラス山脈), *Pseudofumea* (アトラス山脈), *Luffia* (欧州), *Bacotia* (欧州, ネパール, 日本) などの諸属と近縁であると考えられる. 本属と同様に両櫛歯状の雄の触角を持った *Psyche* 及び *Proutia* 属からは, 良く発達した雄交尾器の uncus や, 前翅中室先端前部に R_{4+5} 脈によって付属室が形成されるなどの諸点で異なる. これらの属が 1 系統群を形成しているとすれば, 本新属はその系統発生の初期段階で分岐し

た原始的なメンバーである可能性が高い。

本種のミノは、*Proutia* 属などのミノに概形が似ているが、細長い植物の破片をミノの外壁に直立するように付着する点が特異で、一見するとミノから棘が生えているような外観をしている。このような被覆物の付着の仕方も、この群としては他に例が見られない。

ミノの付着物や蛹化場所（ススキに似た植物の葉裏）などから判断すると、本種の幼虫は森林の地上で枯れたり分解中の高等植物の葉や茎を摂食していると考えられる。

本新属の発見は、今後東アジア、特に中国大陆の温帯から亜熱帯にかけて、本群の未知の属が発見される可能性を示唆している。

(Accepted May 15, 2002)